



US005650054A

United States Patent [19]

Shen et al.

[11] Patent Number: **5,650,054**[45] Date of Patent: ***Jul. 22, 1997**

[54] **LOW COST ROOM TEMPERATURE
ELECTROCHEMICAL CARBON MONOXIDE
AND TOXIC GAS SENSOR WITH HUMIDITY
COMPENSATION BASED ON PROTONIC
CONDUCTIVE MEMBRANES**

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[*] Notice: The term of this patent shall not extend
beyond the expiration date of Pat. No.
5,573,648.

[21] Appl. No.: **522,946**

[22] Filed: **Sep. 1, 1995**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 381,718, Jan. 31, 1995, Pat.
No. 5,573,648.

[51] Int. Cl.⁶ **G01N 27/407**

[52] U.S. Cl. **204/412; 204/421; 204/424;
205/781; 205/783.5; 205/784; 205/786.5;
205/788**

[58] Field of Search **204/412, 421-429;
205/781, 783.5, 784, 786.5, 788**

References Cited**U.S. PATENT DOCUMENTS**

3,366,559	1/1968	Hughes et al.	205/742
4,024,036	5/1977	Nakamura et al.	204/427
4,025,412	5/1977	LaConti	204/195
4,227,984	10/1980	Dempsey et al.	204/430
4,324,632	4/1982	Tantram et al.	204/195
4,474,648	10/1984	Tantram et al.	204/1
4,478,704	10/1984	Miyoshi et al.	204/412
4,536,274	8/1985	Papadakis et al.	204/433
4,664,757	5/1987	Zupancic et al.	204/426
5,080,775	1/1992	Yamauchi et al.	204/421
5,118,398	6/1992	McElroy et al.	204/153.1
5,126,035	6/1992	Kiesele et al.	204/415
5,133,857	7/1992	Alberti et al.	204/425

5,164,053	11/1992	Razaq et al.	204/153.18
5,173,166	12/1992	Tomantschger et al.	204/412
5,228,974	7/1993	Kiesele et al.	204/415
5,302,274	4/1994	Tomantschger et al.	204/412
5,344,546	9/1994	Kiesele et al.	204/415

OTHER PUBLICATIONS

Sung B. Lee, Anthony Cocco, Darioush Keyvani and G.
Jordan MacLay, *Humidity Dependence of Carbon Monoxide
Oxidation Rate in a Nafion-Based Electrochemical Cell*,
vol. 142, No. 1, Jan. 1995.

Mahlon S. Wilson, Fernando H. Garzon, Kurt E. Sickafus,
and Shimshon Gottesfeld, *Surface Area Loss of Supported
Platinum in Polymer Electrolyte Fuel Cells*, vol. 140, No.
10, Oct. 1993.

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[57] ABSTRACT

A low cost room temperature electrochemical gas sensor with humidity compensation for sensing CO, alcohol vapors and other toxic analyte gases has a solid protonic conductive membrane with a low bulk ionic resistance. A sensing electrode and a counter electrode, optionally a counter electrode and a reference electrode, which are separated by the membrane, can be made of mixed protonic-electronic conductors, or can be made of a thin electrically conducting film such as platinum. A reservoir of water maintain the solid protonic conductive membrane at constant 100 percent relative humidity to compensate for ambient humidity changes. Embodiments of the inventive sensor also include an electrochemical analyte gas pump to transport the analyte gas away from the counter electrode side of the sensor. Analyte gas pumps for the inventive sensor include dual pumping electrodes situated on opposite sides of the membrane, and include a means for applying a DC power across the membrane to the sensing and counter electrodes. Another embodiment of the inventive sensor has first and second solid protonic conductive membranes, one of which has a sensing electrode and a counter electrode separated by the first membrane, and the other of which has dual pump electrodes situated on opposite sides of the second membrane.

65 Claims, 6 Drawing Sheets